Increase Your ROI Today by Optimizing Your Refrigeration with Continuous Commissioning Using Remote Management Tools

Emre J. Schveighoffer, President
National Resource Management, Inc.

ABSTRACT

For decades refrigeration has been the target for improving and optimizing energy efficiency. Most of the effort dealt with the mechanical side, including compressors, condensers, and the controls that manage them. Today we also see enhancements in the type of refrigerants being used. This article will focus more on the evaporator side, including temperature and defrost control, and monitoring performance by measuring evaporator coil temperature and compressor amps, which is then used to diagnose state, to recommission, and to optimize operation. This is then followed by continuous performance monitoring, known as continuous commissioning of the system.

The basis for this article comes from the fact that all refrigeration systems are or should be sized to maintain temperature during the hottest day of the year. Additionally, it is common for systems to be oversized for those hot days. Depending on the size of the cooler or freezer, or the value of the product stored, many have redundant systems where either could handle the entire load.

Therefore, one of the overlooked opportunities for saving energy is the evaporator fan motor (heater) that operates 24/7 even after the setpoint is achieved. This article will attempt to detail how end users have realized 30-50% energy savings through proper application of safely managing evaporator fan operation and defrost. It will also discuss end users who have taken something complicated and were able to change their own perspective and change behavior with simple, user friendly, web-based tools.

DESCRIPTION OF EXISTING FACILITIES

The two facilities discussed in this article include: 1) Life Technologies (LT) in Carlsbad, CA, a biotech company with two freezers and eight coolers having a combined 22 independent condensers, most of which most are redundant systems; 2) Marquez Brothers (MB) in the City of Industry, CA, a Mexican cheese and yogurt distributor having four large warehouse coolers, as well as a cash and carry area with two coolers and one freezer.

LT coolers and freezers were found to be set up with time clocks that would alternate weekly between redundant systems in order to ensure equal compressor operation. This also meant that electric defrosts in freezers would operate as scheduled, even though refrigeration was not operating every other week. All were controlled and monitored by a sophisticated control system with one glycol probe for alarming.

Most MB coolers were operating without defrost clocks, and off-cycle defrost was the norm. Some of the equipment was 20+ years old and required maintenance.

PROJECT DESCRIPTION

Both projects included installing new networked controls, a gateway used to monitor controllers and stream their data to a remote central server, electronically commutated (EC) motors where possible, and air destratifier fans in the tall coolers and freezers.

The new controls were installed as an overlay to existing controls such that existing controls were used as a backup to new controls. Configuration was such that new controls could be switched into bypass mode, thus allowing pre-existing controls to operate the refrigeration. The system would communicate through a gateway to a central server, and data was continuously collected by the gateway and only sent to the server based on change of value (COV). After installation of the new control system, systems were allowed to operate under existing controls but monitored for a long enough period to establish a baseline for maintained temperatures and equipment run times. After the initial baseline was established, the new control system was activated and control strategies tuned to optimize energy savings.

Both sites qualified for substantial utility incentives, and the web-based system was used to record, measure, and verify energy savings.

Southern California Edison (SCE) wanted to study the MB project in greater detail and provided additional funding to install instrumentation, including power meters and pressure transducers on the four largest condensers. SCE engineers published the results in an emerging technologies article that is available at http://www.etcc-ca.com/images/stories/et_08.10_ibrmcs_final_report.pdf. Results from that report are included in this article.

SYSTEM ARCHITECTURE

The system architecture is displayed in Figure 1, showing:

- Refrigeration spaces and equipment being controlled.
- A control panel containing all of the networked controllers and the gateway.
- A local router that is configured to securely allow data to be sent and received through clients network.
- The data flow via internet to remote server, which then serves the data to a user.

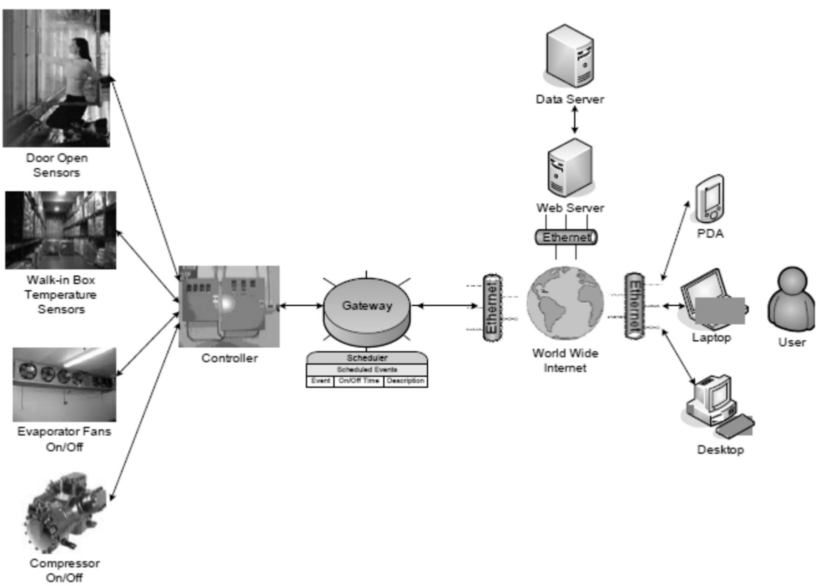

Figure 1. Hardware Architecture (from SCE report)

Some considerations in deploying this architecture were that users would not be required to maintain a local server, access would be available to multiple users from any browser, and the skills required for installation and setup would be minimized. Effort was made to minimize any system integration requirements, and ease of use by a non-technical end user was the primary consideration. (If it was too difficult to use no one would use it; it had to be as easy to use as booking a flight on Southwest.) The data had to be presented in ways that were easy to relate to the operation.

The gateway self-configures to the controllers connected to it (plug and play). As soon as the gateway is connected to an internet-accessible network, it seeks and makes the connection to the remote server, and the server recognizes the site and configures itself to begin receiving data. The server is then used to label each refrigerated zone or device that is reporting so that clients can associate the data with their local equipment. The gateway has analog and digital inputs that can be used to monitor compressor amps, door openings, and meter pulses. It also has 10 digital outputs that can be used to schedule loads like lighting or others.

OPTIMIZING CONTROL STRATEGIES

The installer has the task of using the online setup tool to link the data being sent to the server so that users can view status and performance. After setting up the site and commissioning all of the controls, each controller is set to bypass mode for a period ranging from a few days to two weeks. This allows a technician to observe how the equipment was performing prior to engaging the new control strategies. The performance items monitored are space temperature, apparent differential, evaporator coil temperature, compressor starts, compressor run time from the current, and defrost profile.

After the initial period of observation of data and trend profiles, the technician can configure each controller to match the setpoint of the existing controls, as well as optimize control strategy, including differential, defrost, and evaporator fan cycling. Then the system is allowed to operate for 1-2 weeks, and performance is again analyzed.

See Figure 2 for one of the gateways with the coolers and freezers connected to it. This shows the real-time space temperature and status of controllers, along with statistical information, including 24-hour average temperature, number of calls for cooling and compressor starts during the past 24 hours, the percent of time cooling was on, compressor run time, and run time for the previous 7 days.

Figure 2 provides a very quick view of how each zone was performing and which zones had issues. Note that all of the cold rooms shown had two or more zones for redundancy; it is easy to see which zone tended to be more dominant or provide most of the cooling. Note the last column showing evaporator fan run times and how they were well below the 100% prior to new controls. There is a column showing 3rd probe, which was the temperature in the glycol well used for alarm purposes. In addition to the new controls, all the shaded pole evaporator fan motors were replaced with new EC motors that used 60% less energy.

In the shipping area, three of the cold rooms had glass doors on one wall used for picking products to fill orders, and the control system was used to monitor the dew point from which the anti-sweat heaters were pulsed ON/OFF to match the amount of heat needed to prevent moisture on the doors and frames.

Figures 3 and 4 represent some examples of individual trends that were used to tune and set strategies.

There were four gateways installed at Life Technologies, controlling a total of 22 zones and those with door heaters, resulting in annual energy savings of 649,913 kWh. Run times were reduced by an average of 24.7% for compressors and 45.2% for evaporator fans. This project

Life Technologies Gateway 1
5781 Van Allen Way, Carlsbad CA 92008
Tel: 760-815-6362

Carlsbad/Palomar, CA
Last Updated on Jan 14 2010, 12:53 pm PST - Fair
Temperature 17°C, Humidity 46%, Dewpoint 5°C

Log Out: emrejs5
Help
Fans used to run 100% now only operate % Highlighted

NRM Mini CoolTrol			Temperature °C					Status					Starts 24 Hr.			% Run 24 Hr.			% Run 7 Days		
Description	Content	Status	Space	Evap	3rd	SP	24hr	Mode	Dfrst	Sol	Fan	Amps	Sol	Comp	Fan	Sol	Comp	Fan	Sol	Comp	Fan
Cooler 1018 Zone A	_		4.6	2.8	4.1	4	4.3	Run	Off	On	On	10.4	29	29	156	15.4	18.2	32.2	15	17.8	31.6
Cooler 1018 Zone B	_		5.2	5.2	5.2	4	4.6	Run	Off	Off	Off	0.6	31	32	135	16.5	19.2	39.6	15.5	19.3	37.3
Cooler 1019 Zone A	_		17.4	15.1	18.6	18	18.2	Run	Off	Off	On	0.2	64	65	159	15.9	22.1	39.5	16.6	22.6	39.3
Cooler 1019 Zone B	_		18	16.3		18	18.6	Run	Off	Off	On	0.4	0	0	161	0	0	22.1	46.6	0	55.7
Cooler 6016 Zone A	_		4	0.5		4	4.5	Run	Off	Off	Off	0.4	28	28	107	19.9	21	32.5	16.1	22.1	29.8
Cooler 6016 Zone B	_		3.7	3	4.3	4	4.1	Run	Off	Off	Off	0.4	45	45	161	16.2	18.3	33.1	14	16	29.8
Cooler 6024 Zone A	_		3.6	0.4	6	4	4.6	Run	Off	Off	On	0.2	113	113	111	44.2	47.1	67.8	39	43.7	60.6
Cooler 6024 Zone B	_		3.8	-0.5		4	5.6	Run	Off	Off	On	11.6	113	113	110	46.9	53.6	72.5	42.5	54.9	65
Freezer 1017 Zone A	_		-18.1	-20.4		-20	-18.8	Run	Off	On	On	20.7	21	94	65	47.8	56.3	57.9	37	46.8	47.9
Freezer 1017 Zone B	_		-17.7	-17.4		-20	-18.5	Run	Off	Off	Off	0	26	76	67	45.1	54.3	55.9	31.3	48.7	42.8

Figure 2. Typical Summary Page with Statistics

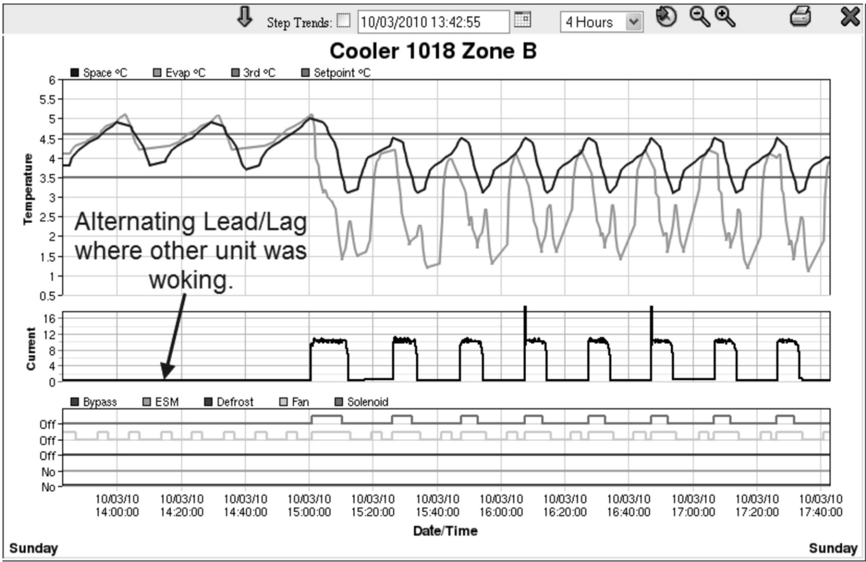

Figure 3. Example Trend at Life Tech

qualified for a 46% utility incentive from San Diego Gas & Electric, which brought the simple payback down to 1.35 years, or an ROI of 73.9%.

At Marquez Brothers, the total measured savings was 249,090 kWh. Run times were reduced by an average of 26.7% for compressors and 57.4% for evaporator fans. After SCE utility incentives, the project realized a simple payback in 0.63 years, with an ROI of 159%. This site's utility meter was monitored by one of the three gateways, and after several months of tracking, the total facility energy reduction was 18-22%. Considering that the project only addressed 8,000 square feet of coolers in a 200,000-square-foot facility, we estimate that the total refrigeration savings was 40-50%.

The main utility power meter could be read as shown in Figure 5.

Since all data collected reside on the data server for a period of 18 months, the continuous commissioning tool has the ability to calculate run times from the historical data. The tool provides a summary for 22 one-week periods, as shown in Figure 6.

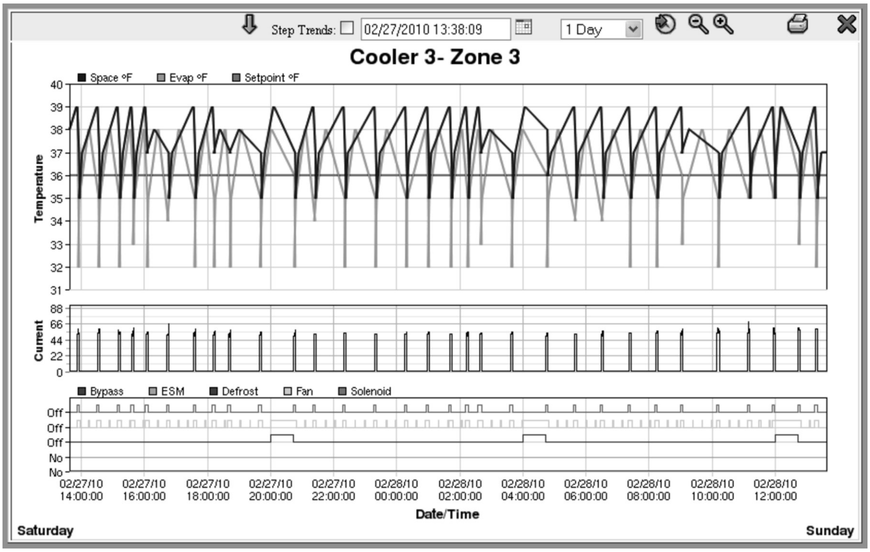

Figure 4. Example Trend at Marquez Brothers

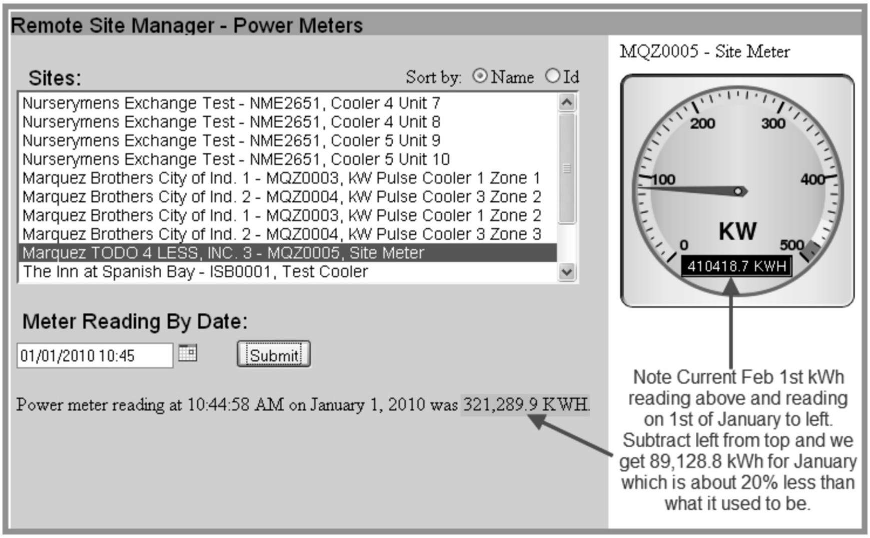

Figure 5. Example of Power Meter Display

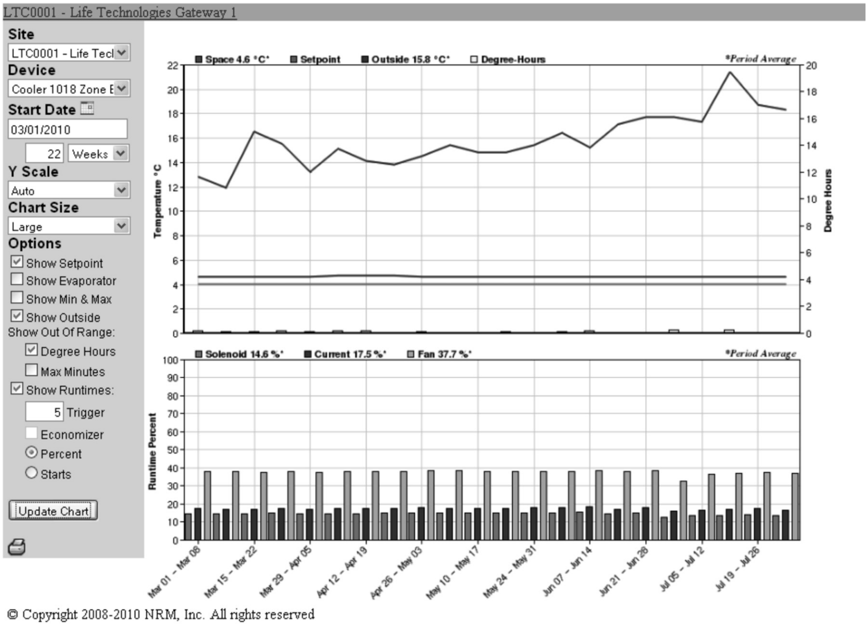

Figure 6. Example of Run Time and Temperature Trend

CONTINUOUS COMMISSIONING OR PERFORMANCE MONITORING

The challenge of all energy conservation efforts is to be able to ensure that after initial commissioning the project will continue to deliver savings to the end user and the utility that helped fund the project. To that end, the equipment affected in the project must be monitored or recommissioned periodically. Since these projects had real-time data that could be viewed and analyzed by both end users and technicians on an ongoing basis, performance was viewed at least daily or weekly, depending on any ongoing issues. The server was also configured to send temperature alarms and alerts as emails and text messages to mobile devices whenever any zone was operating out of acceptable range. This allowed users to be more proactive in maintaining and optimizing performance. Alarm messages were sent when a problem started, with another message when the condition cleared. The emails contained an attachment of the operating trend for the previous 4 hours leading up to the alarm.

Some of the key issues to look for were the number of starts per day, percent of time calling for cooling compared to actual compressor run time, and coil temperature out of acceptable range (indicating a defrost issue). As an example, one of the Marquez cooler zones had a compressor that was short-cycling over 2,000 times per day; since there were two refrigeration systems in that cold box, it was not caught until the remote monitoring system was installed. See Figure 7.

An important part of the commissioning process was to train local personnel who were responsible for observing and maintaining proper temperatures. One of the interesting outcomes at Marquez was that the company controller also receives the alarms and is able to analyze the trends, knowing when to contact his refrigeration contractor to investigate improper operation. This is a major behavioral change, since the controller is paying greater attention to the $3,000 per month reduction in utility costs. There is a direct connection to the energy savings going to the bottom line of the company. Having been in energy conservation for over 30 years, this writer sees the attention to performance as a welcome result. In subsequent meetings with the controller, we learned that the ease of use and understanding of what he was looking at made it worth the few minutes per day to take a look at performance, especially since he has over $2 million worth of product at risk at any given time.

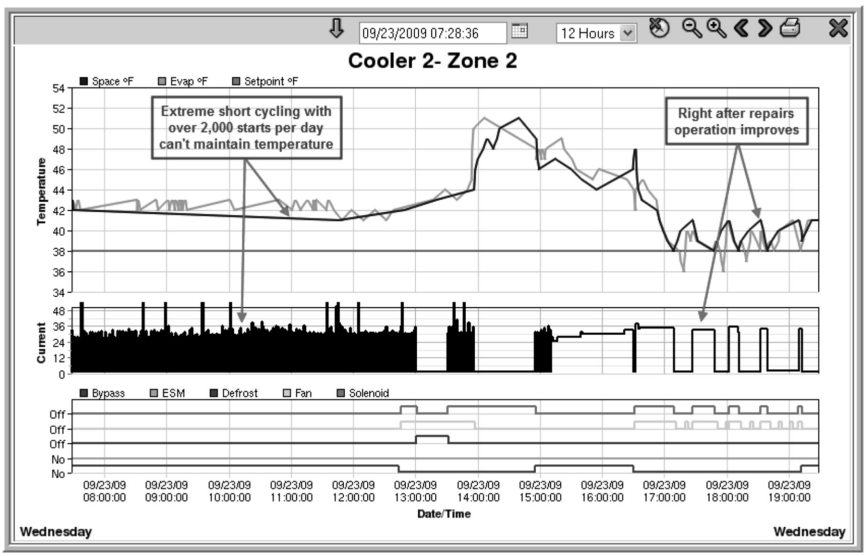

Figure 7. Trend Showing Compressor Short-cycling

CONCLUSION

Numerous studies by respected researchers and universities have stated that of all the mechanical refrigeration and HVAC systems in use, over 80% have issues with regard to performance that result in inefficient operation. A Texas A&M study indicated that, using continuous commissioning, one could realize and maintain 20-40% additional energy savings over time by alerting users when performance drifts. Having been involved with several thousand refrigeration retrofits, this is easy for me to confirm; the benefits of having real time performance data far outweigh the small added expense. In fact, one of the impressive outcomes at Harvard University is that the chefs and kitchen managers in all of the campus dining areas use the system daily to manage and monitor their refrigeration, reporting thousands of dollars saved by receiving early warning of issues relating to potential product loss.

The ease of internet access has made refrigeration energy efficiency much easier to implement and verify savings for both end users and utilities. It also makes it easier to demonstrate operation and simplify the qualification process for obtaining incentives offered by utilities.

References

SCE report created for Emerging Technology, available at http://www.etcc-ca.com/images/stories/et_08.10_ibrmcs_final_report.pdf.

ABOUT THE AUTHOR

Emre Schveighoffer, President, CEO of National Resource Management, Inc., was born in Hungary to peasant farmers. His family emigrated to the US when he was ten, during the Hungarian revolution in 1956. After growing up in New Jersey and working in construction to put himself through college, he graduated from Newark College of Engineering with a Bachelor of Science in Mechanical Engineering. In 1970 he moved to Long Beach, CA, where he held various positions as a quality control technician for a wire company, was a real estate associate assisting developers/builders, and entered the energy conservation field in 1980, marketing lighting and other energy-saving equipment. After holding sales positions with several nationally recognized leaders in the lighting retrofit business, in 1989 an offered position required a move to Massachusetts.

In 1991 he founded National Resource Management, Inc. (NRM) to design and implement lighting retrofit projects throughout New England. After achieving considerable success, NRM hired its first employee in 1994 and went on to develop a new refrigeration control system that was able to deliver energy savings well above expectations; it included control of refrigeration, free winter cooling, evaporator fans, and anti-sweat door heater control. Since 1994, NRM has helped thousands of customers, including some 6,000+ installations. In 2002, NRM developed its award-winning, easy to use, web-based remote site manager system that enables clients to manage their refrigeration over the internet, including alarming, trending, and diagnostics, thus ensuring product safety. NRM has grown to 60+ employees, and Emre and his engineering team continue to create innovative solutions and improve technology in the area of refrigeration.

Emre is married to Janelle and has two wonderful sons, Steven age 34, who works at the company as a software engineer, and Michael age 31, who has worked at NRM for past 10 years in a variety of positions. Emre can be contacted at emrejs@nrminc.com.